Building of a qualification and a skill development program within the ENEN-III European Project

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1. Introduction and Background

The ENEN III project covers the structuring, organization, coordination and implementation of training schemes in cooperation with local, national and international training organizations, to provide training to professionals active in nuclear organizations or their contractors and sub-contractors. The training schemes provide a portfolio of courses, training sessions, seminars, and workshops for continuous learning for upgrading knowledge and developing skills. The training schemes allow individuals to acquire qualifications and skills, as required by the specific positions in the nuclear sector which will be documented in a training passport. The essence of such passport is to be recognized within the EU by the whole nuclear sector which provides mobility to the individual looking for employment and an EU wide recruitment field for the nuclear employers.

The Sustainable Nuclear Energy Technology Platform (SNETP) Education, Training and Knowledge Management (ETKM) Working Group recently published a report that addressed skill gaps that were predicted to materialise over the next two decades with the retirement of about 30% of the existing workforce. This predicament will be exacerbated when new build is taken into consideration. The requirement for technical and professional engineers/scientists were considered to be in their thousands/year for a decade or more for most Member States across the whole of the nuclear industry spectrum. Although new recruits joining the industry will have appropriate academic qualifications their understanding and knowledge of the business in many cases would be lacking. It is predicted that many of these recruits would be experienced personnel from other industries, but would again lack the knowledge and appreciation of the nuclear industry. It is imperative that all new recruits acquire a basic, fundamental knowledge of the business at a very early stage of joining the industry to enable them to work safely and productively.

In several Member States various organizations, largely universities and/or other higher educational institutions but also utilities have developed life-long learning type courses that address the fundamentals of the nuclear industry. Many may not have been accredited by an independent authoritative body and some may not meet the industry’s criteria (Learning outcomes, LO). As this foundation knowledge is imperative to both the employer and employee it is prudent that such courses contain a core syllabus that will satisfy accreditation and ECVET principles.

This paper outlines the qualification program of an introductory fundamental course for non-nuclear graduates. It has sufficient breadth and comprehension to be appropriate for any graduate (or equivalent), post graduate discipline i.e. STEM* but has been specifically prepared with non-nuclear engineers and professionals, as required by the ENEN III project.

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2. Trainees Prerequisites

It is clear from the beginning that all the trainees participating in these training schemes are graduate students at least to the level of master degree as defined by the European Commission. No knowledge in the nuclear engineering area is needed, as the purpose of the training scheme is to provide a wide and useful background of the nuclear science and technology area for non-nuclear graduates.

3. Job Profiles

The target group consists of engineers supporting the operation of a Nuclear Power Plant in the following positions:

• Programme Engineer

• Performance/Reliability Engineer

• System/Component/Maintenance Engineer

• Safety Assessment Engineer

It includes plant personnel, contractors and subcontractors.

These job profiles tend to cope with all the different positions that any graduate would have when he/she starts working in the nuclear industry, having no nuclear education at all, or not enough to meet the requirements of a nuclear engineer.

In such a special field as nuclear is, there is strong need of basic knowledge about nuclear safety and nuclear culture as it will impact on every work that could be done in a daily-work for a graduate. The training is intended to be enough to cover all the different aspects needed to start working in the nuclear area with sufficient nuclear culture.

3.1 Knowledge, skills and attitudes required for the fulfilment of the job tasks

As the training scheme is supposed to provide a base knowledge for the non-nuclear graduates, there is no need to make different trainings for the different job positions, as it is not intended to give such specific training. In case of needing that training, it is covered in Generation III specific training for design and construction.

The knowledge, skills and attitudes required for the fulfilment of the job task are the next ones:

Knowledge
Nuclear Administrative Aspects Knowledge
Nuclear Engineering Fundamentals Knowledge
Basic Knowledge of Plant Systems and Component

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	Basic Knowledge of Plant Operations
Skills	
	Working with Self-developed Engineering Tools or Off-the-Shelf Tools
	Presentation and Documentation of Work Results
	Teamwork/Communication
Attitudes	
Individual, Critical Examination of the Tasks	

As it can be seen in the table, the knowledge requirements cover the more needed and basic fundamentals that can be useful to begin working in the nuclear area. The special knowledge needed to understand how the nuclear industry works is vast, and is should be covered widely.

Once the basic fundamentals are implemented, it should be completed the plant systems, components and operations knowledge, as it will be necessary to safe a successful starting working for a nuclear plant.

The skills developed with such knowledge are common with some job positions described in Ref. [8]. The skills let the trainees to start being self-dependent doing the engineering tasks, as being able to work in groups, make calculations with the engineering tools and document and present the results.

The attitudes of the trainees will be critical with the tasks and surely individual-based, to be have a useful personal point of view based on the knowledge they have acquired and the skills they have developed.

4. Knowledge Skills and Attitudes in Terms of Learning Outcomes

As it is told in D 1.2, Ref. [6], introductory courses should be seen as informative and educational. The course should demonstrate the complexity of the nuclear industry but emphasize the industry is well regulated and meets exacting standards.

For being qualified a program should meet the requirements in terms of educational goals; learning outcomes; and teaching, learning and assessment strategy, Ref. [7]. These elements are described in the following sections.

4.1 Educational Goals

The study program aims at:

- Providing students with skills and knowledge to work safely in the nuclear industry
- Develop competences in the area of nuclear engineering
- Educate students who can use the acquired knowledge and skills in various fields of the nuclear industry such as nuclear safety, radiation protection, etc.
- Educate students to understand how a nuclear power plants works

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- Provide students with the minimum safety culture knowledge to understand the complexity and safe operation of the nuclear power plants.

4.2 Learning Outcomes

The definition of the Learning Outcomes has been done in WP 1.2. From its rev 3 report, the LO are listed below:

Lecture	Learning Outcomes
Fundamentals of reactor operation	1. Knowledge of Neutron interaction. 2. Understanding of Fission process in a nuclear reactor. 3. Know the neutron multiplication in a nuclear reactor. 4. Understanding the Reactor kinetics. 5. A full understanding of the Control rod effect 6. A full understanding of the Soluble poisons 7. Knowledge of Burnable poisons. 8. Appreciate the Reactivity temperature effects. 9. Fission products poisoning. Dead Time. 10. Knowledge of Neutron Sources, Sub critical multiplication and Bending curves.
Radiation and Radiological Protection	1. A full understanding of the sources, types of radiation and hazards associated with nuclear processes. 2. Knowledge of radiation detection, monitoring equipment and protection. 3. Understanding of Ionising Radiation Regulations. 4. Know how ionising radiation interacts with matter and its effects on living organisms. 5. Know the units and terms used in radiological protection and the sources of and approximate level of exposure.
Criticality Safety Management	1. Knowledge of nuclear properties of fissile materials, concepts of criticality, critical mass, impacts of moderators, reflectors, shapes, as they relate to assembling critical formations of fissile materials. Both homogeneous and heterogeneous fissile systems to be included. 2. Appreciate the influence of the above on the design of storage facilities, shipping configurations etc. 3. Developed an understanding of the philosophy of criticality safety management. 4. Knowledge and experience of applying simple calculations in criticality assessment. 5. Reviewed relevant national and international standards and lessons learned from past criticality incidents.

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Lecture	Learning Outcomes
Nuclear Safety Case	1. Understand the requirement for a modern standards nuclear safety case; 2. Have an appreciation of the main building blocks of a modern standards nuclear safety case; 3. Have an awareness of the main supporting processes and methodologies used in developing a modern standards nuclear safety case. 4. Perform safety calculations in support of the preparation of a model Safety Analysis Report for a nominated example. 5. Develop and quantify simplified fault and event trees for a specific example. 6. Prepare an abbreviated Safety Analysis Report for a specific example.
Nuclear Regulation	1. Review the history and development of nuclear regulation in the appropriate Member State. 2. Describe the relationship of the regulatory authority with other organizations both inside and outside of the government 3. Recognise the regulatory and licensing requirements of the regulatory authority 4. Determine how the regulatory body evaluates licensee performance 5. Discuss the regulatory body's enforcement process
Nuclear Fuel Cycle	1. An understanding of the key processes involved in the nuclear fuel cycle. 2. Describe the major disciplines needed for each stage of the NFC. 3. An appreciation of the safety and environmental considerations involved in the cycle. 4. An understanding of the choice of technologies for each key stage of the NFC. 5. Knowledge of the worldwide capacities and economical markets involved in the cycle as well as an appreciation of political influence.
Fuel Manufacture	1. Understand the origins of uranium ore concentrates (UOCs) and processes employed to convert them to nuclear fuel. 2. Appreciate why UOCs are not reactor grade material and the reasons for further purification. 3. Identify the wastes and effluents produced from the conversion processes. 4. Explain why the difference in processing technology for enriched and natural uranium. 5. Knowledge of uranium hexafluoride preparation and reasons for its production.
Uranium-235 Enrichment	1. Understand the physical factors affecting enrichment for various isotopes. 2. Appreciate the history of enrichment from gaseous diffusion to laser enrichment.

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Lecture	Learning Outcomes
	3. Explain the concept of separative work units and reasons for multiple stages. 4. Explore the sensitivity of uranium enrichment. 5. Knowledge of worldwide capacities.
Reactor Technology	1. Describe how a nuclear reactor works. 2. Identify the type of fuel used in nuclear reactors. 3. Explain why a nuclear explosion is not possible in a nuclear reactor. 4. Identify some of the main features of nuclear reactors. 5. Identify some of the safety features that have been designed into nuclear reactor system. 6. Identify the systems of the nuclear power plant. 7. Knowledge the functions of the systems of the nuclear power plant. 8. Compare the performance of nuclear reactors with fossil fuel power stations.
Spent Fuel Reprocessing	1. Knowledge of storage/transportation of spent fuel from reactor site to reprocessing site. 2. Understand isotopic composition of spent fuel and origins of fission products and implications of burn-up. 3. Explain key stages of the reprocessing cycle and reasons for technology selection. 4. Appreciate the chemistry of the actinides and fission products. 5. Identify the key waste arisings from reprocessing. 6. Debate the merits of reprocessing compared with other options. 7. Discuss the safety issues of reprocessing and storage of liquid wastes.
Nuclear Waste Management	1. Categorisation and types of radioactive wastes. 2. Origins of nuclear wastes. 3. An appreciation of approaches to nuclear waste management. 4. Knowledge of the encapsulation and immobilisation of waste in a range of waste forms. 5. A grounding in the techniques of nuclear waste processing to give waste forms suitable for storage and ultimate disposal 6. Understanding of general performance and safety assessment methods.
Decommissioning	1. Appreciate reasons for decommissioning and type of structures waiting decommissioning. 2. Understand the concepts of hazardous waste management, minimisation, transport and disposal. 3. Be aware of the range handling techniques available and reasons for their selection 4. Know about equipment cleaning and surface decontamination 5. Be aware of safety and legal issues in decommissioning 6. Be exposed to techniques of decommissioning project costing and analysis.
Waste Disposal	1. Discuss the various options for waste disposal and their constraints.

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Lecture	Learning Outcomes
	2. Identify the major waste arisings and their environmental impact. 3. Consider stakeholders' interests. 4. Appreciate international guidelines for waste disposal. 5. Understand the potential of radionuclide migration into the environment and ways of abatement.
Social and Environmental Considerations	1. State some of the facts that: - supporters of the use of nuclear energy use to substantiate their position; - critics raise regarding the use of nuclear energy. 2. Suggest how environmental concerns regarding the use of non-nuclear methods of electrical generation might be alleviated with the use of nuclear energy. 3. Using a solid knowledge base of all of the previous outcomes, develop a position which either supports or rejects the use of nuclear energy for peaceful purposes. **4.** Defend a position which either supports or rejects the use of nuclear energy for peaceful purposes.

4.3 Teaching, Learning and Assessment Strategy

The teaching should be based mainly on lectures, complemented with simulator work (if possible). The lecturer should emphasize on active discussions in every lecture, for example, the last 5 to 10 minutes of a 50 minute lecture. The lecturer should be available for tutorials.

The learning process should be progressive; from fundamentals to more complex knowledge during the education. It should be state very clear which of that knowledge is essential and which is informative. This fact will help to meet the Learning Outcomes, focusing on the aspects that will develop competences more that those which only can be used as extra information.

The assessment method should be Learning Outcomes oriented, Ref. [2]and [7]. To meet that goal, it at least a 50% of the assessment should be **formative** (assessment FOR learning), assessment that helps to inform the lecturer and the students as to how the students are progressing. It can be carried out both at the beginning or during the course. The rest of the assessment should be **summative**, which helps to measure the students' performance and the acquired knowledge. With the sum of both kinds of assessment the LO will be met easier.

In D 1.2, Ref. [6], it is recommended that either of these assessment exercises would have to be acceptable to an independent accreditation body like an academic institution.

5. References

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